High-Fidelity Virtual Environments

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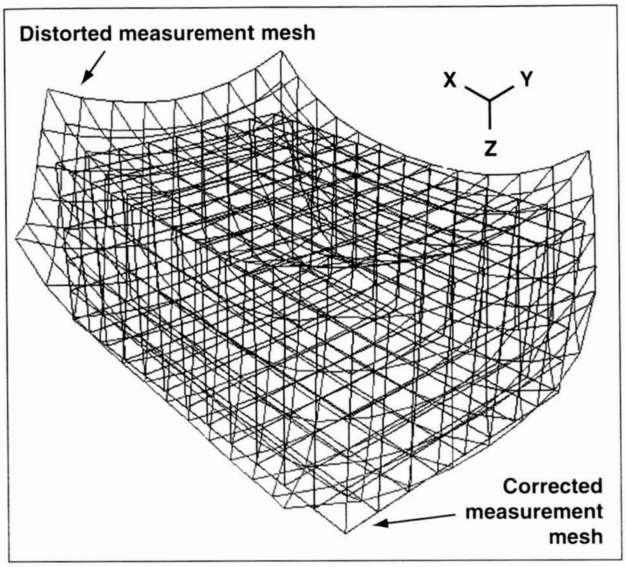

Fig. 1. Mesh of position-sensor distortion.

Virtual environments are personal simulators. They are interactive, head-referenced computer displays that create an illusion that causes their users to feel displaced to another location. This illusion is created through the operation of three types of equipment: (1) sensors, such as head position sensors, to detect the operator's body movements, (2) effectors, such as stereoscopic displays, to stimulate the operator's senses, and (3) special-purpose hardware to interlink the sensors and effectors to produce sensory experiences resembling those encountered by inhabitants immersed in a physical environment. In a virtual environment this linkage is accomplished by a simulation computer. In a head-mounted teleoperator display the linkage is accomplished by the robot manipulators, vehicles, control systems, sensors, and cameras at a remote work site. Both virtual environments and head-mounted teleoperator displays have applications in mechanical design, data visualization, robotics, and as aids for mechanical assembly.

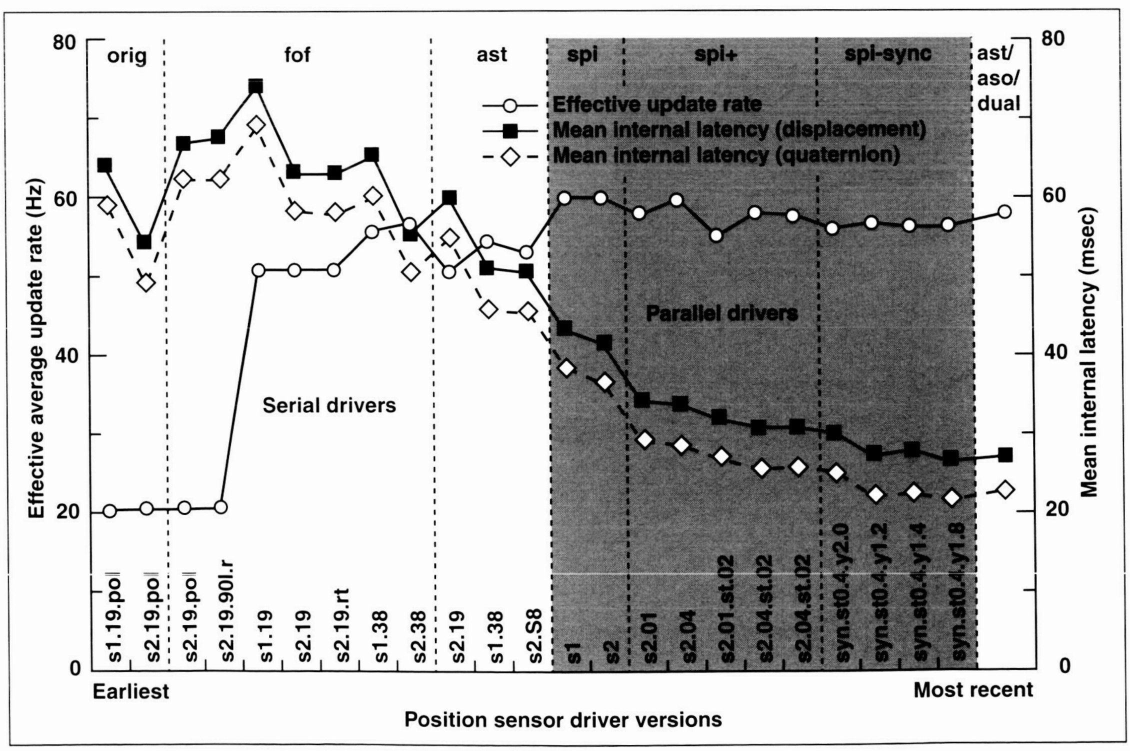

Fig. 2. Performance of improved position-sensor drivers.

Fig. 3. Subject tracing a virtual path with a virtual ring attached to her hand.

Current virtual environment systems commonly use electromagnetic position trackers to sense operator head and hand positions in order to generate virtual environment simulations. The most common of these sensors suffer from uncorrected distortion in measurements of operator position; when interfaced to simulation computers, they produce objectionable time lags. Though these defects are acknowledged problems, their effect on the objective and subjective aspects of operator behavior within immersing virtual environments has not been studied and they have not been minimized.

The objective of the current work has been to measure and correct the position distortion of common position sensors (first figure) and to minimize simulation system visual lag during virtual environment rendering (second figure). These improvements are then tested with a manual tracing task in which operators attempt to move a virtual ring over a virtual path (third figure, left and center right) without making contact with it. Path complexity and ring diameter are changed (third figure, right) to study the precision with which operators can accomplish the task as a function of display conditions.

The precision and accuracy with which users can interact with virtual objects in virtual environments have been improved by correcting spatial distortion in common position sensors used to produce virtual environment simulations and by improvements in the latency and update rates with which these environments may be created. Position and orientation of a FasTrak position sensor were measured and corrected comparing linear and nonlinear interpolation schemes adapted from the computational geometry used in computational fluid dynamics. These algorithms have been ported to run on popular computer graphics workstations.

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